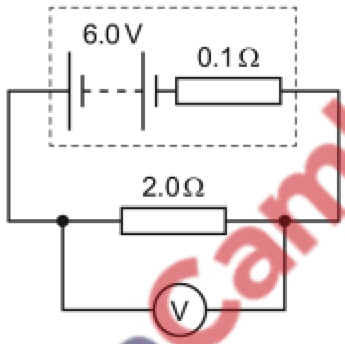
Paper 1

1.

The diagram shows a circuit.



What is the reading on the voltmeter?

A 0.3 V **B** 5.7 V **C** 6.0 V **D** 6.3 V

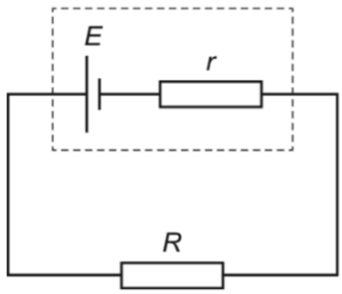
Ans: B

- V = 6 – (0.1 x (6/(0.1 + 2))) = 5.7

2.

A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a resistor of resistance R.

A maximum power P can be dissipated by the resistor without overheating.



What is the maximum value of E if the resistor does not overheat?

A $R\sqrt{\frac{P}{(R-r)}}$ **B** $R\sqrt{\frac{P}{(R+r)}}$ **C** $(R-r)\sqrt{\frac{P}{R}}$ **D** $(R+r)\sqrt{\frac{P}{R}}$

Ans: D

$P = I^2 R$

$E = I(R+r)$

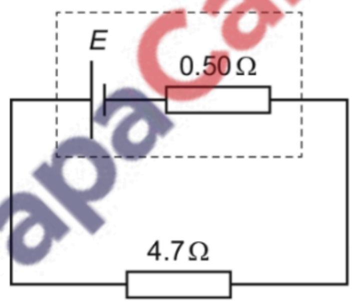
$\Rightarrow I = \frac{E}{R+r}$

$P = \left(\frac{E}{R+r}\right)^2 R \Rightarrow \sqrt{\frac{P}{R}} = \frac{E}{R+r}$

$\therefore E = (R+r)\sqrt{\frac{P}{R}}$

3.

A cell of electromotive force (e.m.f.) E and internal resistance 0.50 Ω is connected to a resistor of resistance 4.7 Ω.



The maximum power that can be dissipated by the resistor without overheating is 0.50 W.

What is the maximum value of E for the resistor **not** to overheat?

A 1.4 V **B** 1.5 V **C** 1.7 V **D** 2.9 V

Ans: C

$0.5 = I^2 \times 4.7$

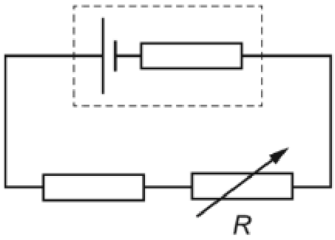
$I = \sqrt{\frac{0.5}{4.7}}$

$E = \sqrt{\frac{0.5}{4.7}}(0.5 + 4.7)$

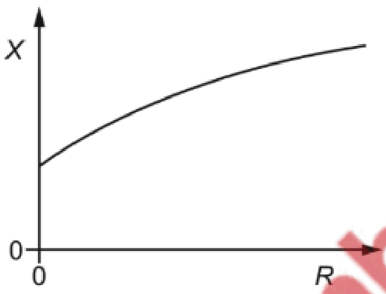
$= 1.7 V$

4.

A fixed resistor and a variable resistor are connected in series with a cell that has an internal resistance, as shown.



The graph shows the variation of a quantity *X* with the resistance *R* of the variable resistor as *R* is increased from zero to its maximum value.



What could *X* represent?

A the current in the circuit

B the electromotive force of the cell

C the potential difference across the internal resistance

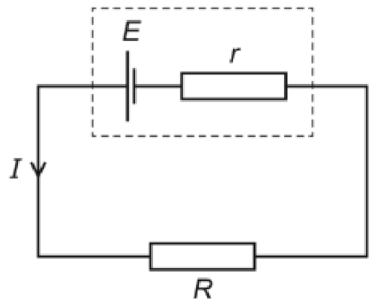
D the terminal potential difference across the cell

Ans: D

- When R = 0, X is small (but not 0)
- Not A, because when R = 0, current is not small.
- Not B, because emf of cell is constant.
- When R increases, I decreases, thus Ir decreases. So not C.
- Ir decreases, which means (E – Ir) will increase, so D.

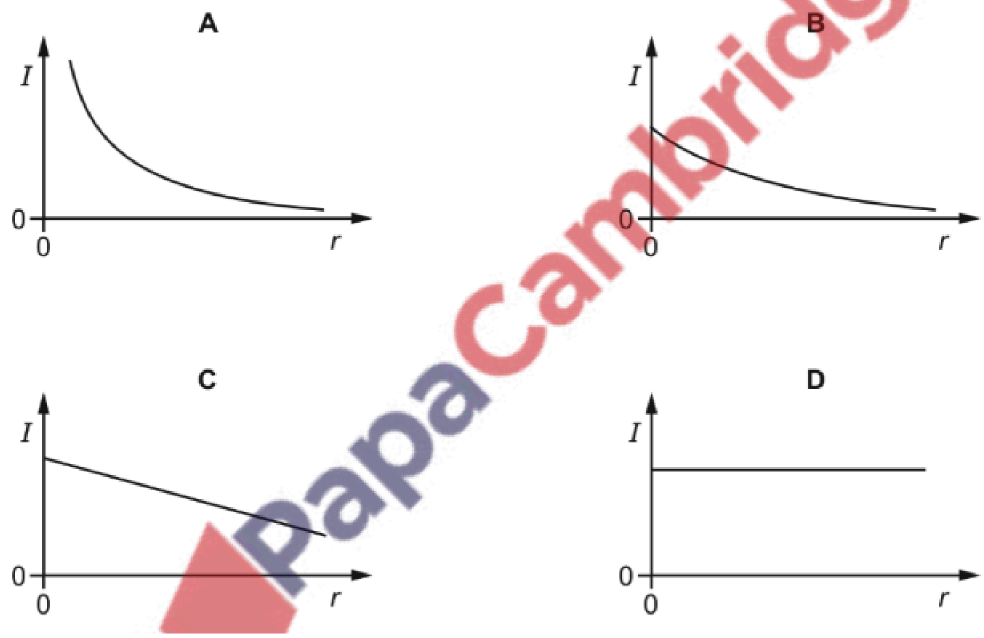
5.

A cell of internal resistance *r* and electromotive force (e.m.f.) *E* is connected in series with a resistor of resistance *R*.



The resistance *R* and the e.m.f. *E* remain fixed. The internal resistance *r* of the cell changes over time.

Which graph best shows the variation of the current *I* in the circuit with the internal resistance *r*?



Ans: B

- When r increases, I decreases; rules out option D
- E = I(R + r)
- I = E/(R + r)
- This relationship is similar to y = 1/x; inverse relation
- Thus the shape of graph will have an asymptote; rules out option C
- I = E/(R + r); the R causes the graph to shift towards LHS, so there is a y-intercept; the E makes the graph bigger.
- When r = 0, I is not infinite because there is still R, so there will be a y-intercept; rules out option A

6.

When a battery is connected to a resistor, the battery gradually becomes warm. This causes the internal resistance of the battery to increase whilst its electromotive force (e.m.f.) stays unchanged.

As the internal resistance of the battery increases, how do the terminal potential difference and the output power change, if at all?

	terminal potential difference	output power
A	decreases	decreases
B	decreases	unchanged
C	unchanged	decreases
D	unchanged	unchanged

Ans: A

$V = IR$

$I = \frac{E}{R + r\uparrow}$ $\therefore I\downarrow$

$\therefore V\downarrow$

$P = I^2 R$

$\because I\downarrow \therefore P\downarrow$

7.

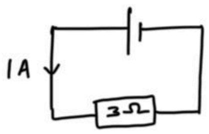
A cell is connected to a resistor of resistance 3.00 Ω. The current in the resistor is 1.00 A.

A second identical resistor is added in parallel. The current becomes 1.93 A.

What are the e.m.f. E and internal resistance r of the cell?

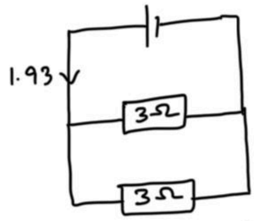
	E / V	r / Ω
A	0.113	3.11
B	3.04	0.0358
C	3.11	0.113
D	9.34	6.34

Ans: C



$V = 3 \times 1 = 3V$

$3 = E - 1r$



$V = 1.5 \times 1.93 = 2.895V$

$2.895 = E - 1.93r$

options A & D can be eliminated.
use trial & error for B & C.

$3 = 3.04 - 1(0.0358)$ ✓

$2.895 = 3.04 - 1.93(0.0358)$ ✗

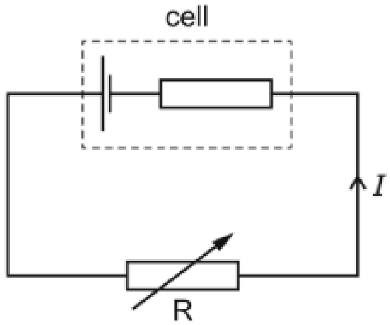
$3 = 3.11 - 1(0.113)$ ✓

$2.895 = 3.11 - 1.93(0.113)$ ✓

∴ option C

8.

A cell with internal resistance is connected to a variable resistor R as shown.



The resistance of R is gradually decreased.

How do the current I and the terminal potential difference across the cell change?

	current I	terminal potential difference across cell
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Ans: C

$I = \frac{E}{\downarrow R + r}$

$\therefore I \uparrow$

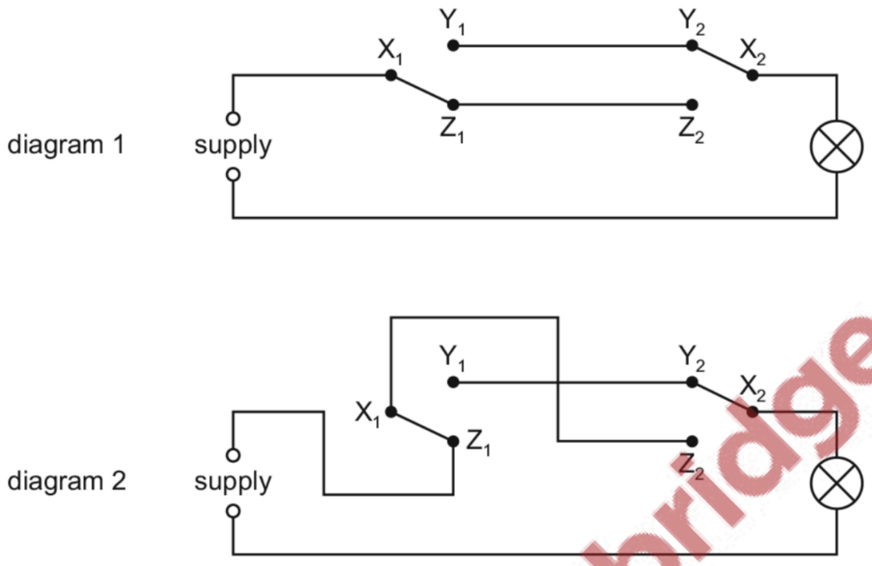
$V = E - Ir$

since $I\uparrow$, $V\downarrow$

9.

Diagram 1 shows a lamp connected to a supply through two switches.

During repairs, an electrician mistakenly reverses the connections X_1 and Z_1, so that Z_1 is connected to the supply and X_1 to the other switch at Z_2, as shown in diagram 2.



Which switch positions will now light the lamp?

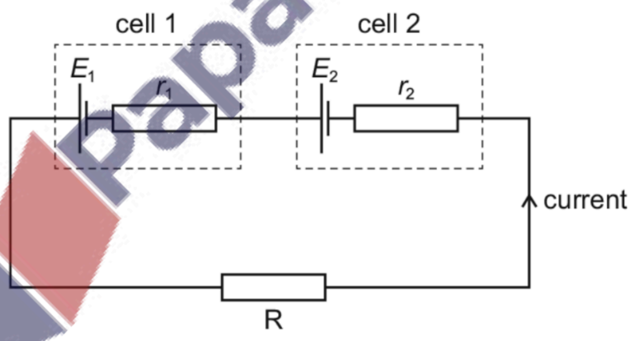
A	X_1 to Y_1	X_2 to Y_2
B	X_1 to Y_1	X_2 to Z_2
C	X_1 to Z_1	X_2 to Y_2
D	X_1 to Z_1	X_2 to Z_2

Ans: D

- Trace along the path from the supply to the lamp.

10.

Two cells with electromotive forces E_1 and E_2 and internal resistances r_1 and r_2 are connected to a resistor R as shown.



The terminal potential difference across cell 1 is zero.

Which expression gives the resistance of resistor R?

A $\frac{E_2r_1 - E_1r_2}{E_1}$ **B** $\frac{E_2r_1 - E_1r_2}{E_2}$ **C** $\frac{E_1r_2 - E_2r_1}{E_1}$ **D** $\frac{E_1r_2 - E_2r_1}{E_2}$

Ans: A

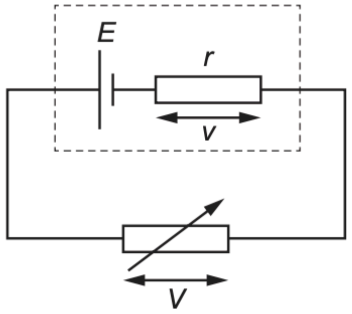
$$R = \frac{V}{I} = \frac{E_2 - Ir_2}{I}$$

$$E_1 - Ir_1 = 0 \Rightarrow E_1 = Ir_1 \Rightarrow I = \frac{E_1}{r_1}$$

$$R = \frac{E_2 - \frac{E_1}{r_1} \times r_2}{\frac{E_1}{r_1}} = \frac{E_2r_1 - E_1r_2}{E_1}$$

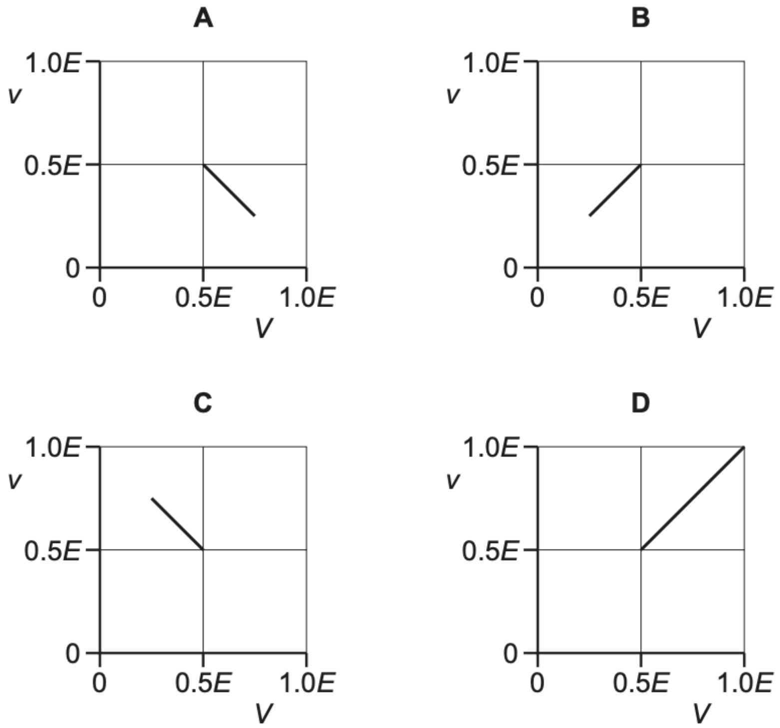
11.

A cell of electromotive force (e.m.f.) *E* and internal resistance *r* is connected to a variable resistor, as shown.



The resistance of the variable resistor is gradually increased from *r* to 3*r*.

Which graph shows the variation of the potential difference (p.d.) *v* across the internal resistance with the p.d. *V* across the variable resistor?

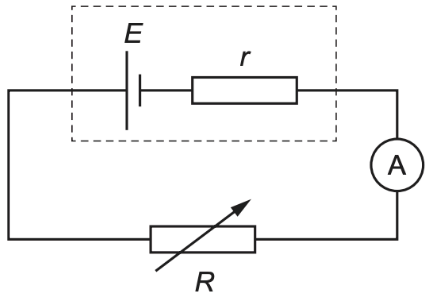


Ans: A

- As resistance of variable resistor is increased, terminal pd increases, and lost volts decreases. This rules out B and D.
- When internal resistance = external resistance, Emf is equally divided between the 2.
- Thus, initially they both get 0.5E.
- When external resistance = 3r, terminal p.d = (3r/4r) x E = 0.75E

12.

A cell has internal resistance *r* and electromotive force (e.m.f.) *E*. The cell is connected in series with an ammeter and a variable resistor of resistance *R*.



When *R* is 10 Ω the ammeter reads 0.3 A.

When *R* is 5 Ω the ammeter reads 0.4 A.

What is the value of *E*?

A 0.5 V **B** 2 V **C** 3 V **D** 6 V

Ans: D

E = (0.3)(r+10) = (0.4)(r+5)

r = 10; E = 6

13.

A cell has a constant electromotive force.

A variable resistor is connected between the terminals of the cell.

The resistance of the variable resistor is decreased.

Which statement about the change of the cell's terminal potential difference (p.d.) is correct?

A The terminal p.d. is decreased because more work is done moving unit charge through the internal resistance of the cell.

B The terminal p.d. is decreased because the current in the variable resistor is decreased.

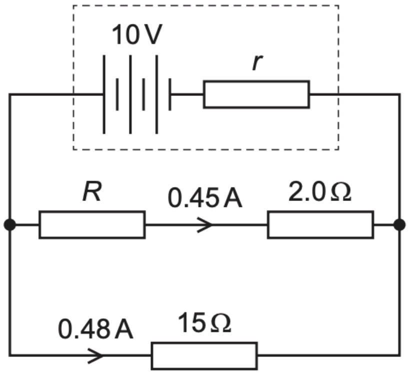
C The terminal p.d. is increased because more work is done moving unit charge through the variable resistor.

D The terminal p.d. is increased because the current in the variable resistor is increased.

Ans: A

14.

A battery of electromotive force (e.m.f.) 10 V and internal resistance r is connected to three resistors of resistances R, 2.0 Ω and 15 Ω, as shown. A current of 0.45 A is in the resistor of resistance 2.0 Ω and a current of 0.48 A is in the resistor of resistance 15 Ω.



What are the values of r and R?

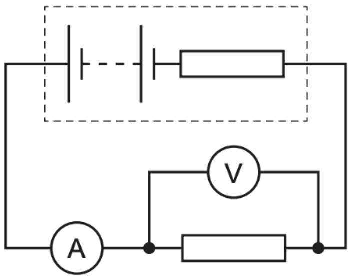
	r / Ω	R / Ω
A	3.0	14
B	3.0	20
C	5.8	14
D	5.8	20

Ans: A

- Terminal pd = 15 x 0.48 = 7.2
- I through r = 0.45 + 0.48 = 0.93
- r = (10 – 7.2) / 0.93 = 3
- 0.45R + 0.45 x 2 = 7.2; R = 14

15.

A battery with internal resistance is connected to a fixed resistor, an ammeter and a voltmeter, as shown.



The battery is replaced by a different battery that has the same electromotive force (e.m.f.) but a greater internal resistance.

What happens to the readings on the ammeter and voltmeter?

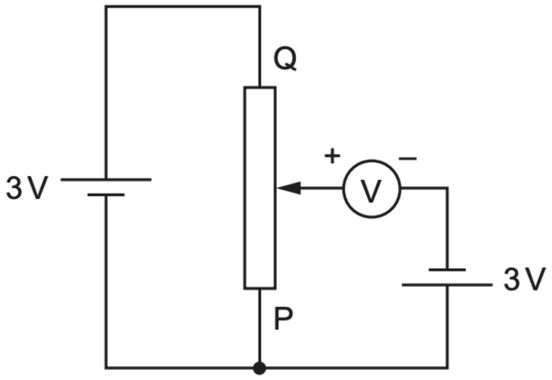
	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	stays the same	decreases
D	stays the same	stays the same

Ans: A

- E = I(r+R)
- When r increases, R still remains the same, because it is a fixed resistor.
- Emf is also same, thus I has to decrease.
- Terminal pd also decrease since IR decreases.

16.

A voltmeter is connected into a circuit with the polarity shown.



The sliding contact is moved to end P of the potentiometer and then to end Q.

What are the two readings of the voltmeter?

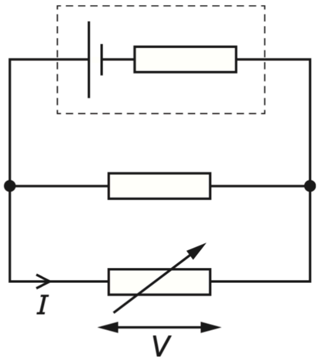
	sliding contact at end P	sliding contact at end Q
A	0 V	3 V
B	0 V	6 V
C	3 V	3 V
D	3 V	6 V

Ans: D

- This is not connected like a usual potentiometer: the –ve end is connected to the +ve end.
- If –ve end was connected to –ve end, they would cancel each other out, given 0V and 3V, which is the typical scenario.
- When contact is at P, only the 3V connected to the voltmeter is measured.
- When contact is at Q, the 3V connected to the voltmeter as well as the other 3V is measured. Since –ve terminal is connected to +ve terminal, they add up to give 6V.

17.

The diagram shows a cell with internal resistance connected in parallel with a fixed resistor and a variable resistor.



The resistance of the variable resistor is decreased.

What happens to the potential difference V across the variable resistor and the current I in the variable resistor?

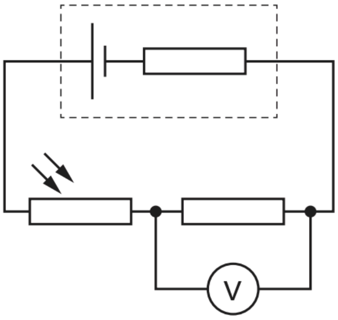
	V	I
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Ans:

- R of variable resistor decreases, so V across it decreases
- E = IR + Ir; IR decreases since V decreases
- Thus Ir has to increase to maintain same emf. Thus I decreases

18.

A cell with internal resistance is connected to a light-dependent resistor (LDR), a fixed resistor and a voltmeter, as shown.



The voltmeter reading increases.

Which quantity decreases as the voltmeter reading increases?

A the charge moving through the cell per unit time

B the energy transferred to the fixed resistor per unit charge

C the intensity of the light incident on the LDR

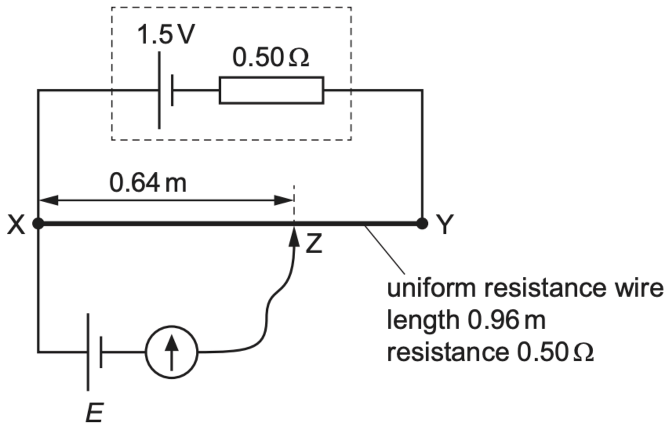
D the terminal potential difference across the cell

Ans: D

- For voltmeter reading to increase, current has to rise
- When current rises, potential drop in the internal resistance rises
- This leads to lower terminal potential difference

19.

A potentiometer circuit is used to determine the electromotive force (e.m.f.) *E* of a cell. The circuit includes a second cell of e.m.f. 1.5 V and internal resistance 0.50 Ω that is connected to a uniform resistance wire XY, as shown.



The resistance wire XY has a length of 0.96 m and a resistance of 0.50 Ω.

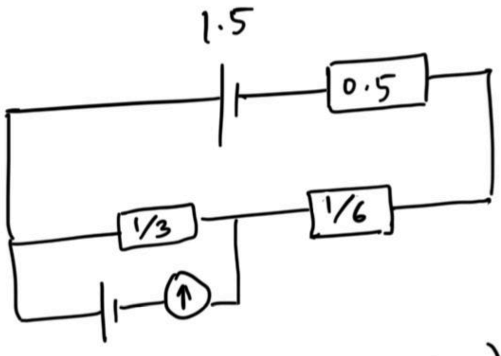
The movable connection Z is moved along wire XY. The galvanometer reading is zero when length XZ is 0.64 m.

What is the value of e.m.f. *E*?

A 0.50 V **B** 0.75 V **C** 1.0 V **D** 1.1 V

Ans: A

- When length = 0.64, R = (0.64/0.96) x 0.5 = 1/3



$1.5 = I\left(0.5 + \frac{1}{3} + \frac{1}{6}\right) \therefore \frac{3}{2}$

V across cell = $\frac{1}{3} \times \frac{3}{2} = 0.5$

-